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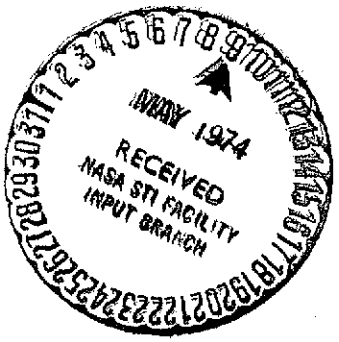
MARS IN THE EYES OF GEOLOGISTS

B. Konovalov

Translation of "Mars glazami geologov," Izvestiya, 20 March 1974, p. 5, Cols. 1-4



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16. Abstract

A discussion by scientists of the Institute of Geology of the Academy of Sciences, USSR on the study of other planets to find out more about early geological development on Earth. It has been ascertained that Mars "aged" before our own planet and this could be useful for supplying comparative material for research. There are many similarities between the Moon, Mars and Earth, volcanic disturbance, type of rock, altitude relief, etc., which may serve, once again, for comparative information.

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MARS IN THE EYES OF GEOLOGISTS

B. Konovalov

The work of geologists is not simply to find a deposit but also to understand why it was formed in that particular place of the planet, and to untangle the chain of reasons leading to the creation of "terrestrial wealth," in order to search for it more effectively in the future. Alas, this chain often goes not only deep into the Earth, but deep into its history -- to those times when gigantic cataclysms rocked the young planet. Time has erased many links of this causal chain, and as paradoxical as this appears, they can only be "restored" by studying other heavenly bodies. That is why the development of space is "manna from heaven" for geologists. Investigation of Mars by spacecraft can be very valuable -- this was the main theme in speeches by scientists of the Institute of Geology of the Academy of Sciences, USSR, meeting at the "round table" of Izvestiya. /5*

"We know," says M. Markov, a doctor of geological and mineralogical sciences, the director of the Laboratory of Comparative Planetology, "that the primary matter of our solar system, from coagulates of which planets were formed, was almost identical. Further development of this matter on different planets can be conditioned by various reasons. On one hand, by the size of the planet, on the other -- its position in the solar system, thirdly -- by the specific features, of which we can only guess.

"Any information which we obtain on other planets of the solar system will make it possible to reveal the general mechanisms of

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* Numbers in the margin indicate pagination in the foreign text.

their development, and, at the same time, to understand better the geological features of Earth's evolution."

"Mars, by its dimensions and density, is situated between the Moon and the Earth or Venus," says P. Kropotkin, a corresponding member of the Academy of Sciences of the USSR. "It is of great scientific interest to compare them. The Earth is the largest in mass and densest of all the cosmic bodies. Calculations show that the Earth must have a large core, consisting of iron (with an admixture of nickel and other elements) -- about a third of its mass. The dense core of Venus is about one-fifth of its mass and Mars -- 4% of its mass, and on the Moon, apparently, there is no core whatsoever."

"But, Mars, Earth and the Moon have approximately the same altitude relief gradient. From the top of the highest peaks to the bottom of the deepest depressions on Mars is 12-14 km (if one does not include the huge volcano Nix Olympica), on the Moon is 11-12 km, on Earth is now 18 km. But if the Earth was suddenly deprived of water, the bottom of the ocean, freed from this weight, would rise and the different on Earth would also be 13-14 km. This similarity between Earth, Mars and the Moon is amazing.

"High- and low-lying areas are distinct from each other in rock formation. On Earth, on continents, the thickness of the Earth's crust fluctuates from 30 to 60 km and consists mainly of granite. In ocean depressions, the Earth's crust is quite thin -- approximately 10 km and is composed mainly of basalts. The Moon's crust in the dark sea areas is also basalts and in the lighter continents -- other rocks, especially anorthosite, according to scientists having the lightest melting fraction of primary matter on the Moon.

"Comparing what is known about Mars, I came to the conclusion that there there are also two types of areas -- high ground and depressions, which are not only different in relief level, but, probably, also have the same thickness of crust with the same chemical and mineralogical composition. On Mars, some rising ground is so bright that is even competes with the polar caps. But if these bright areas are all rising ground, then, in theory, the Martian crust must be thicker here. On the Moon, it consists of anorthosite, on the Earth of granites, and what about Mars? I believe that it would be granite rock. Indeed, on Venus, an instrument, from the Venus-8 spacecraft, detected in the ground a content of potassium, uranium and thorium, which indicates granite composition."

"Photographs, taken by Mariner-9 and by Mars-5, also caused many suprises, especially, that the huge mountain Nix Olympica has a base which is more than 500 km in diameter. How do geologists rate these discoveries?"

"Until recently," says A. Sukhanov, a candidate of geological and mineralogical sciences, "we could only carry out geological comparison of Earth with the Moon. Among the lunar craters there are many huge calderas -- volcanic "depressions," and on Earth there are not as many, and they are much smaller; but, on Earth there are thousands of large cone-shaped volcanoes and on the Moon there are few and they are small."

"After information has been received about Mars, it was found that it occupies the intermediate position in volcano characteristics between the Moon and Earth. But the discovery there of Nix Olympica was unusual -- nothing similar had been encountered in our solar system. It rises 16 km above the high ground which surrounds it. As a whole, Martian volcanoes have similar dimensions to those on Earth. But there were calderas with a diameter of up to 50-100 km on the summits of these volcanoes. There are no large

calderas on volcanoes on Earth, but they are common on the Moon. There appears a comparative series of the three planets: Moon, Earth, Mars.

"Recently, craters, with diameters of from 33 to 160 km, were discovered on Venus. As soon as Venus, Mercury and Jupiter have been studied, we shall be able to find out more about the nature of volcanoes on planets, and which of the features of planets is most important here. From this we shall be able to draw many important conclusions concerning the early history of the Earth."

"Photographs of Mars, taken by satellites, have exploded many myths. Especially, now there is no doubt that the "Martian canals" are a figment of man's imagination; there is not water on Mars. What sort of strange formations are they, why are they so similar to canals, how were they formed?"

"On one of the photographs of the Martian surface, one can clearly see a huge trench 50-80 km in width, stretching for 1000 km around the equator. This is a dark strip, previously called a canal," answers P. Kropotkin, "but now in my opinion, it is of a purely tectonic origin. This type of structure occurs during elongation. On Earth, tectonic trenches such as these are called grabens. The Martian graben is similar to the Jordan River valley and the middle reaches of the Rhine. It can be clearly seen that both sides of this trench are furrowed by ravines.

"On Earth, tectonic trenches are almost always bordered by thermal springs, as for example, grabens of Lake Baykal or central Iceland. It is quite possible that this is also the case on Mars. Rising up through faults, the moisture comes nearer to the surface and partially evaporates. I believe that on Mars, it flowed under layers of sand, down along a firm base, formed

of igneous rock and eroded a channel. Tunnels were formed and the upper layers subsided into them.

"On photographs of Mars, not only ravines of this type were seen, but also a number of real river valleys, with a ramified network of tributaries. The length of these valleys was up to 400-700 km. In their upper reaches, one can clearly see deeply cut canyons, in the lower reaches, channels winding from side to side, so-called meanders, characteristic of river plains, channels, elongation islands between them, river spits.

"How can this coincide since on Mars at the present time, conditions are more severe than they were on Earth before the Ice Age? The atmosphere is very thin. In these conditions, if water rises from above in the form of vapor or liquid, it must evaporate and quickly turn to ice. There is permafrost on Mars.

"The answer is, according to American researchers, that in the recent geological past, there was a warm Interglacial period which they call the fluvial (from the Latin fluvius -- a river). At this time, polar glaciers melted as did those layers of ice, which were alternated with layers, consisting of pulverized particles brought by the wind. The atmosphere was saturated with moisture, rains fell, streams flowed, and rivers scoured valleys. I believe that this fluvial period on Mars corresponds to the middle of the Tertiary Period on Earth, when, 20 million years ago, there was a warm climate everywhere and palm trees grew in Greenland.

"As a tectonist, I am mainly interested in the fact that on Mars expansion forces clearly show themselves, and on Earth are even more active. There are no large trenches on the Moon such as there are on Mars. It is covered with a dense network of fine faults with small upheavals. Since, as yet, we do not know the reasons for these tectonic processes, it would be very

interesting to compare the Earth with Mars and the Moon in this respect. We shall be able to understand better the mechanism which causes fragmentation of the Earth's crust by such comparisons.

"A photograph of a tectonic trench with ravines on its edges, of which we have already spoken, is interesting inasmuch as the fissure which runs parallel to the edges of the trench, is clearly seen on it. This shows that there was a general pressure field active here. One can see a whole series of small craters threaded along this fissure. We can confirm that this was not caused by shock. However, meteorites could have fallen, they would not have created such an accurate tectonic trench. It seems more likely that here gases erupted from the interior.

"On Earth, there are volcanoes where there is little lava, and, on the other hand, those where there is excessive lava. If lava flows out systematically, naturally, high ground will be formed, and a cone-shaped or scutiform volcanic hill will appear. If there is little lava during eruptions, but much gas, this will give the same effect as a bomb or a meteorite, "exploding" owing to the energy of its impact when falling on the planet's surface.

"On the Moon and on Mars, apparently, volcanism, to a greater degree than on Earth, was linked with the upsurge of gases. Bursting from below, they threw aside the surface layers and a circular swell was formed. If this swell was leveled, there would be no special increase in the height of the area."

"There are methods for determining the relative age of surface planets according to the nature of craters, and the degree of their destruction," said A. Sukhanov. "The whole surface of Mars can be divided into several areas, differing in age. It appears, that in the youngest areas of this planet the old craters

are almost completely eroded and covered up by later stratifications, or these are wind deposits, or glacial or of composite origin.

"Comparing these areas with areas on the Moon, of which we have information about the absolute age of rocks, one can roughly estimate when the process of intensive destruction of Martian craters occurred. It appears that it was several hundred million years ago, when the Martian atmosphere, apparently, was denser and more humid. On photographs there are even traces of glacial valleys, which are not there now, since the atmosphere has too little moisture.

"Apparently, the Moon began to cool and loose its activity approximately 3 billion years ago. On Mars, the active change of the relief ended several hundred million years ago. An on Earth it is now flourishing. Mars "aged" earlier than our planet.

"But, it is true that one must note that the Moon is not a completely dead planet, neither is Mars: there one must expect more noticeable occurrences of geological activity.

"How can the study of other planets help science on Earth?"

"The value of all this work," sums up M. Markov, "is the fact that it can give comparative material. Obtaining information allows one to shift to the search for more general mechanisms of planet development. By traveling this path, we should be able to solve such large problems of natural sciences as the development of matter in the solar system, formed from all types of rocks. This problem exceeds the limits of geology; it is significant for other sciences also. On the other hand, when we study planets, we get to know the past of our own Earth. Especially, now it is thought that a lunar stage existed on Earth during its development, which would be very characteristic for

the development of anorthosites. Its traces have remained in places where the oldest rocks appear on the surface, for example, in Scandinavian and Canadian shields.

"If we knew the Moon, Mars and Venus very well, we should be able to understand early stages of the development of the Earth and it would be useful, both in the purely scientific aspect, and in the search for commercial minerals. For example, the formation of huge deposits of iron and uranium ore are linked with the early Precambrian Period. The "roots" of many deposits go back into the past."